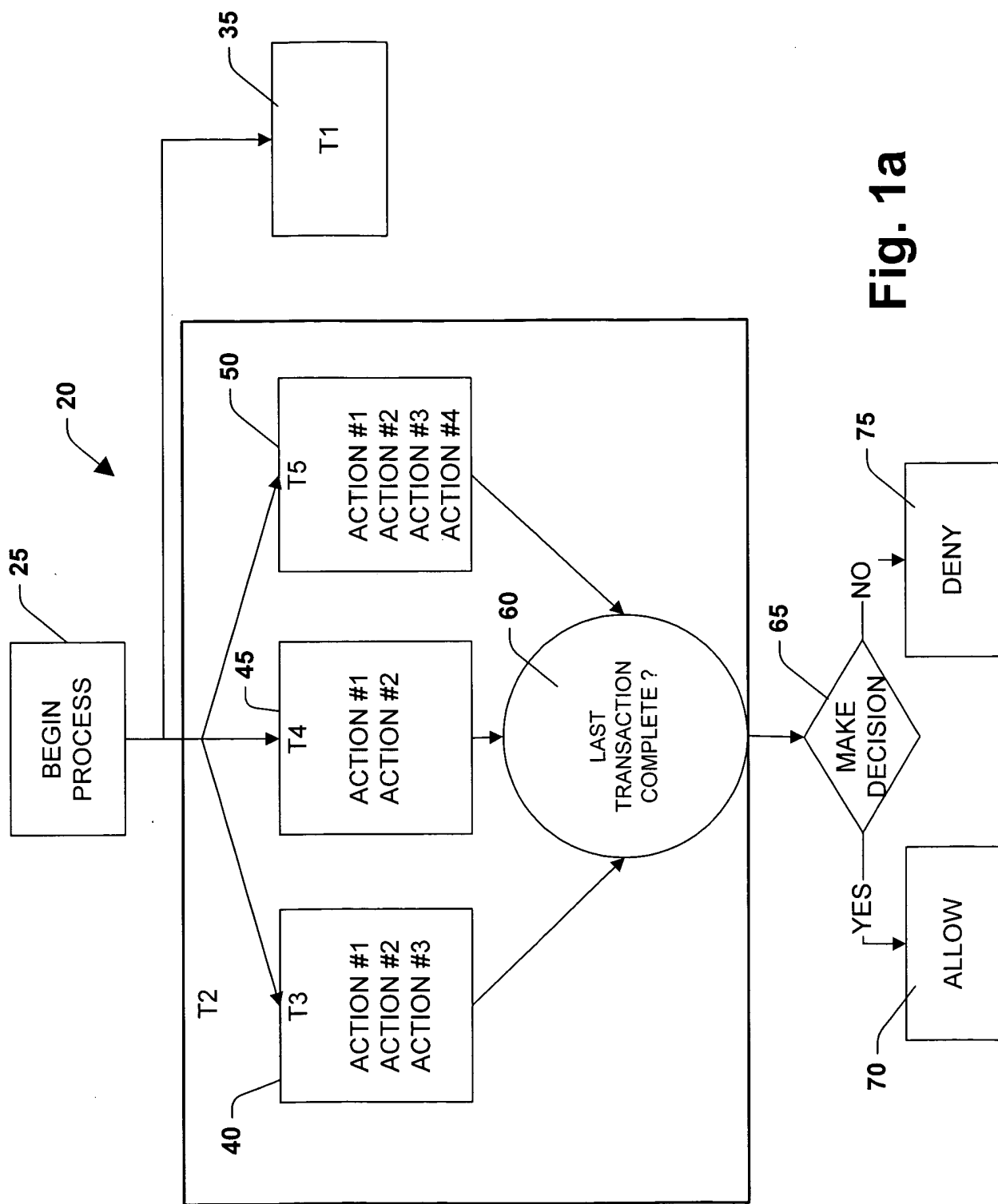


Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100
1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	



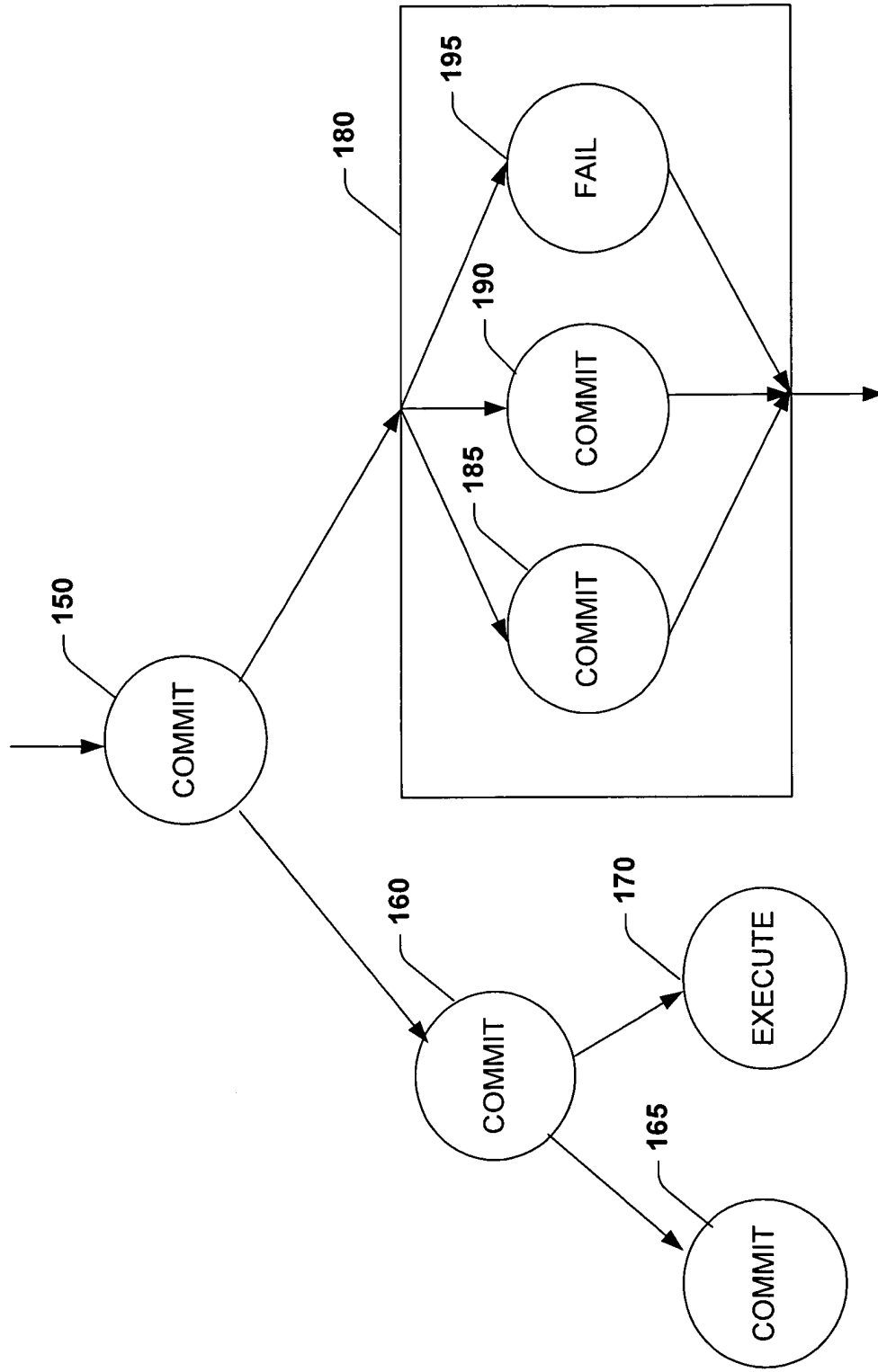


Fig. 1c

COMBINATORS SYNTAX

$$P ::= 0 \mid \alpha \alpha.P \mid P^\perp \mid P \otimes P \mid \text{Cut}(P, P, P) \mid !P \mid (\text{let}(x, y)P)$$
$$\alpha ::= \tau \mid x \mid x \mid \alpha \otimes \alpha$$

STRUCTURAL EQUIVALENCE

1. $\alpha_1 \alpha_2. (\text{let}(x, y)P) = (\text{let}(x, y) \alpha_1 \alpha_2.P)$
2. $(\text{let}(u, v) \text{let}(x, y)P) = (\text{let}(x, y) (\text{let}(u, v)P))$
3. $(\text{let}(u, v)P) \otimes \text{let}(x, y)Q = (\text{let}(u \otimes x, v \otimes y)P \otimes Q)$
4. $(\alpha_1 \alpha_2.P) \otimes (\beta_1 \beta_2.Q) = (\alpha_1 \otimes \beta_1)(\alpha_2 \otimes \beta_2).P \otimes Q$
5. $(\alpha_1 \alpha_2.P) = (\alpha_1 \otimes \beta_1(\alpha_2 \otimes \tau).P) . \beta \in G(P)$
6. $0 \otimes 0 = 0$
7. $!P = P \otimes !P$

Fig. 1d

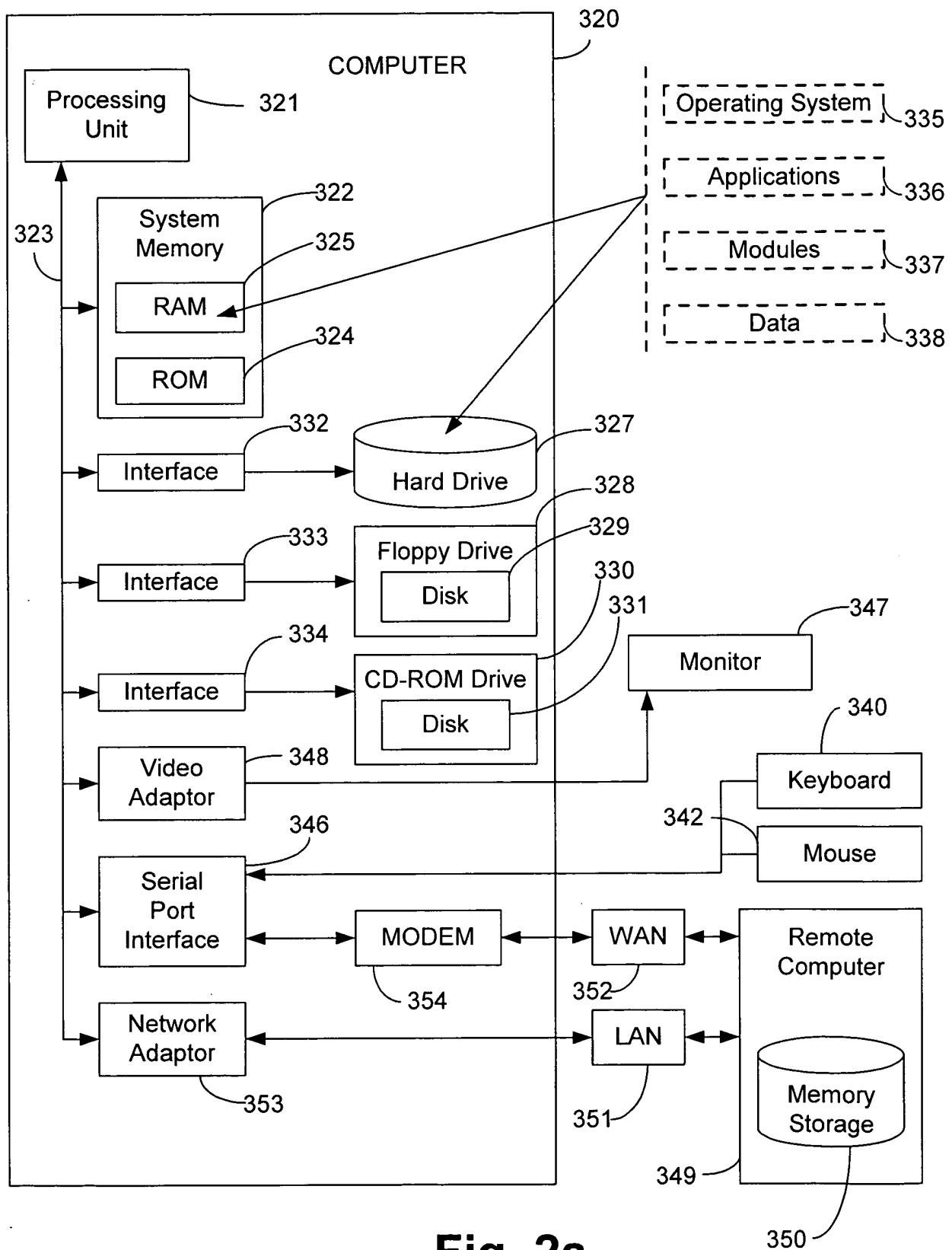


Fig. 2a

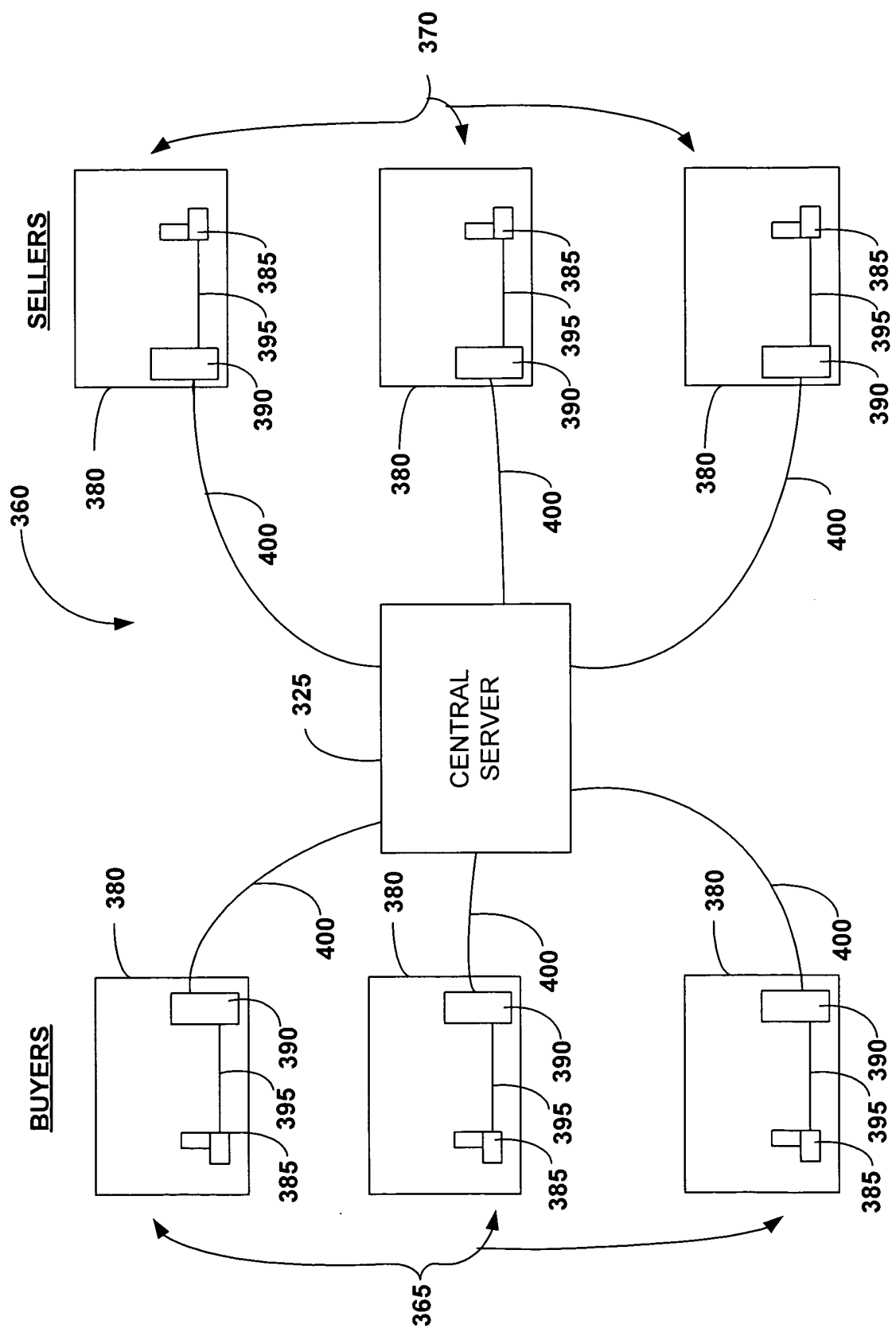


Fig. 2b

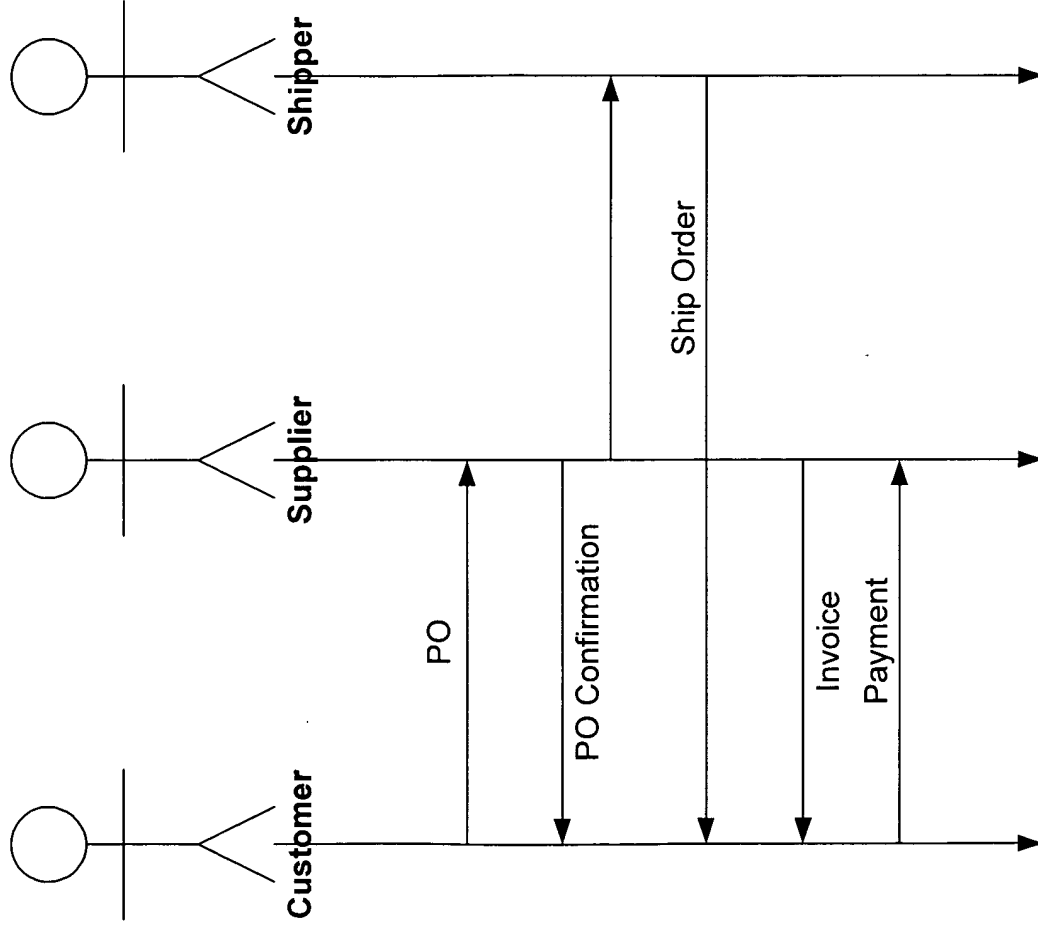


Fig. 3

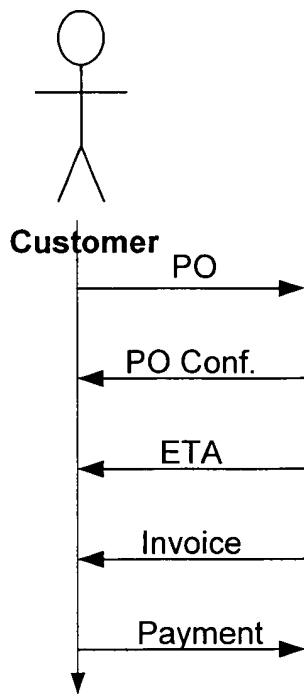


Fig. 4a

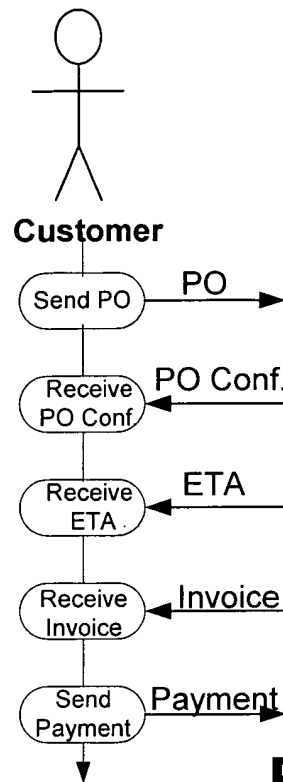


Fig. 4b

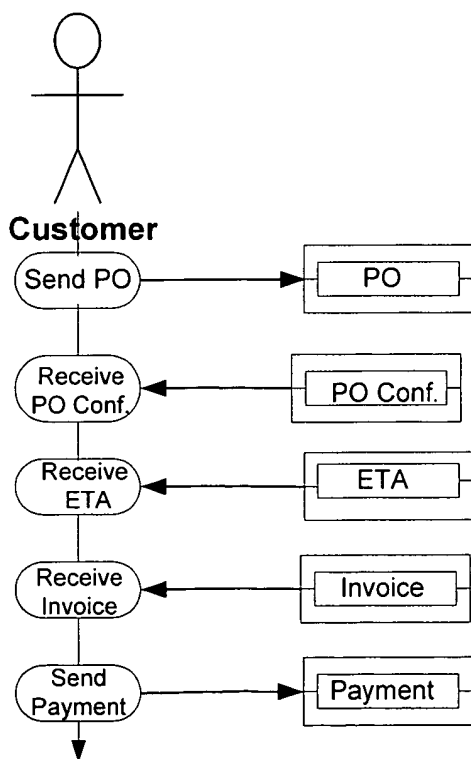


Fig. 4c

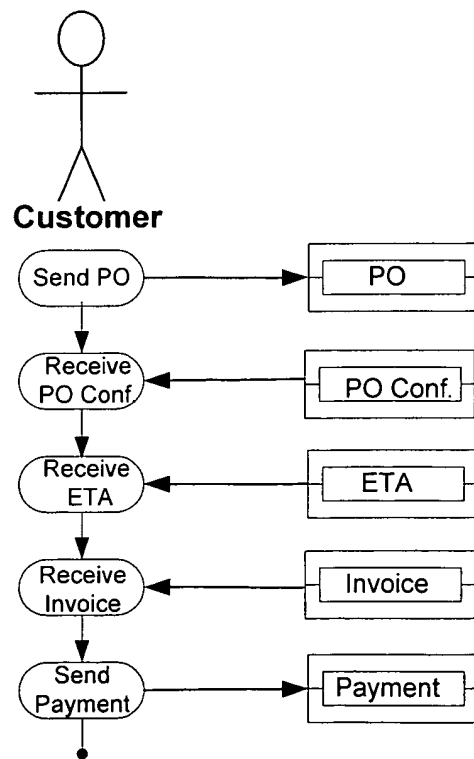


Fig. 4d

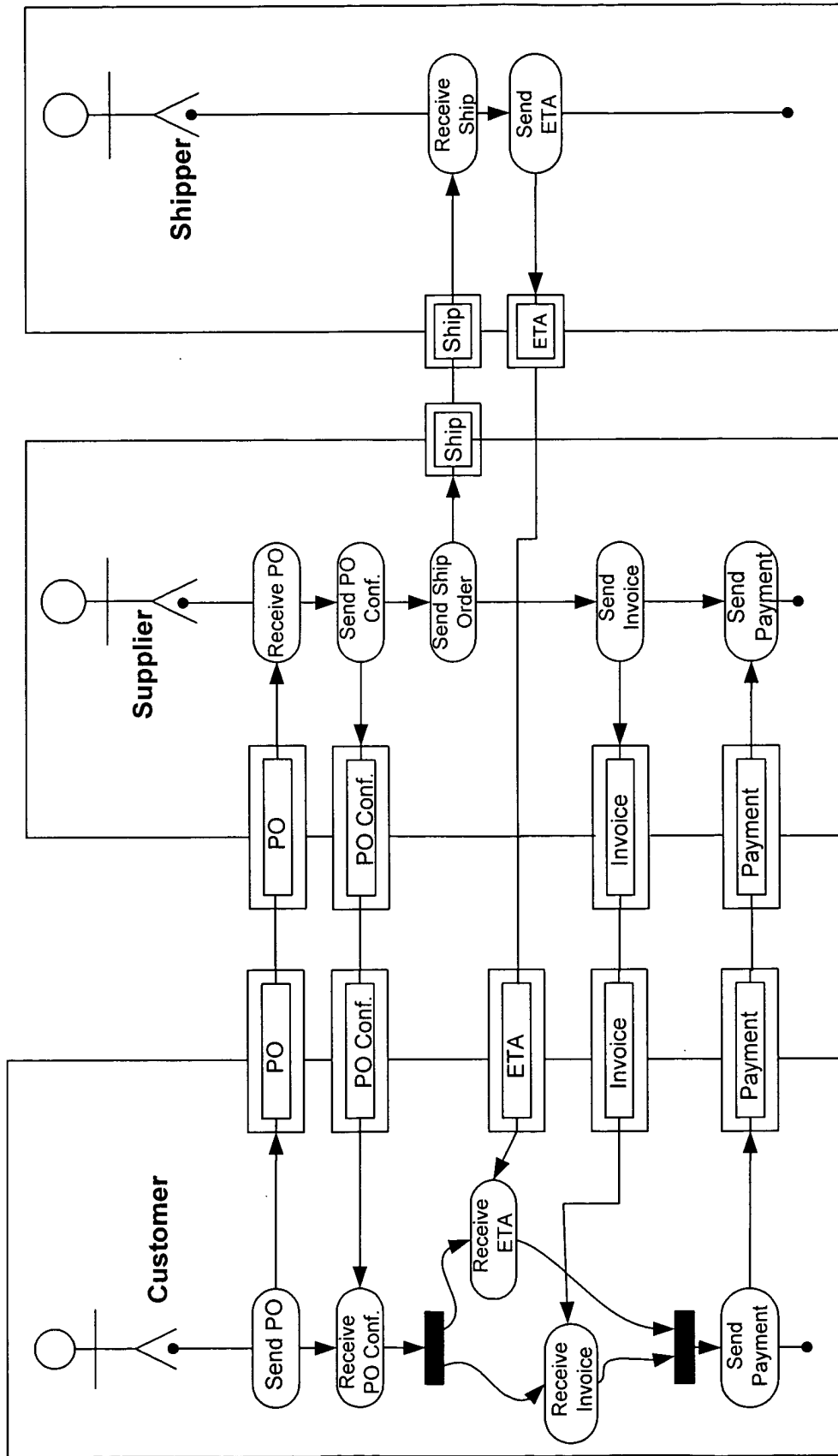


Fig. 5

THE

schedule	::= header? process? contextRef?
header	::= portList? messageList? contextList?
process	::= zero sequence switch map copy partition connect cut
portList	::= port*
messageList	::= message*
contextList	::= context*
zero	::= zero
sequence	::= genericAction* process? contextRef?
genericAction	::= silence action task call return release
silence	::= silence
action	::= source sink
source	::= portRef messageRef contextRef?
sink	::= portRef messageRef contextRef?
task	::= action* contextRef?
call	::= schedRef portRef* messageRef* contextRef?
switch	::= branch* (default process) ? contextRef?
branch	::= case process
case	::= ruleRef msgRef msgRef
map	::= process assignmentList? contextRef?
assignmentList	::= assignment*
assignment	::= messageRef portRef
copy	::= process contextRef?
partition	::= process* contextRef?
connect	::= process process connectionList contextRef?
connectionList	::= connection*
connection	::= portRef portRef
cut	::= process process process contextRef?

Fig. 6

Example
<pre> <schedule name="mySchedule"> <header> <portList> <port name="p0"> <port name="p1"> </portList> <messageList> <message name="m0"/> <message name="m1"/> </messageList> </header> <!-- The schedule body goes here --> </schedule> </pre>

Fig. 7c

Port (EBNF)
port ::= <i>port</i> portName
portName ::= <i>identifier</i>
portRef ::= <i>portRef</i> URI

Fig. 8a

Port (XML)
< ! ELEMENT port EMPTY>
< ! ATTLIST port
name ID #REQUIRED>
< ! ELEMENT portRef EMPTY>
< ! ATTLIST portREF
location CDATA #REQUIRED>

Fig. 8b

Message (EBNF)
message ::= <i>message</i> messageName
messageName ::= <i>identifier</i>
messageRef ::= <i>messageRef</i> URI

Fig. 9a

Action (EBNF)	
action	::= source sink
source	::= <i>source</i> portRef messageRef contextRef?
sink	::= <i>sink</i> portRef messageRef contextRef?

Fig. 11a

Action (XML)	
<! ELEMENT sink	(portRef, messageRef, contextRef?)>
<! ELEMENT source	(portRef, messageRef, contextRef?)>

Fig. 11b

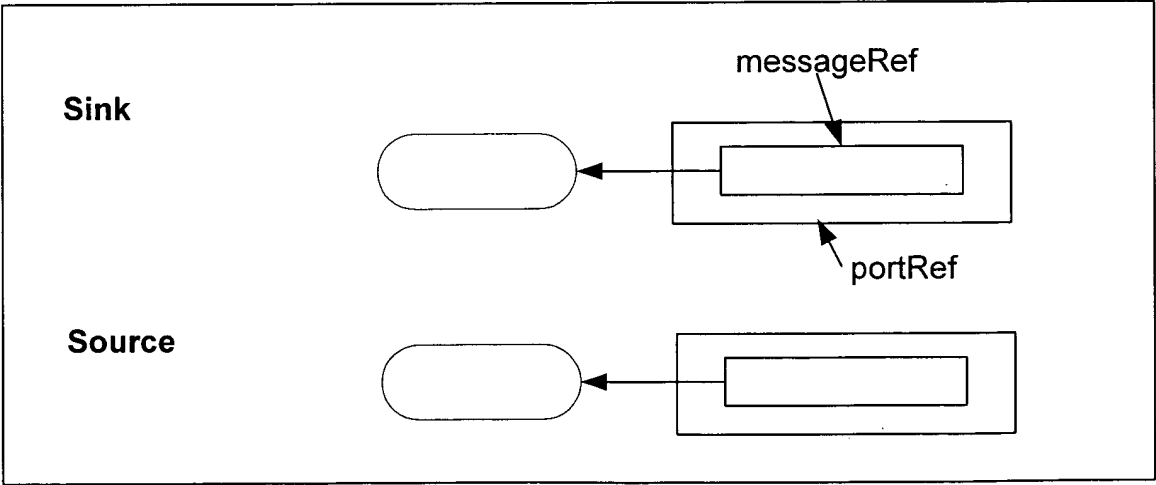


Fig. 11c

Process	
process	::= zero sequence switch map copy partition connect cut

Fig. 12

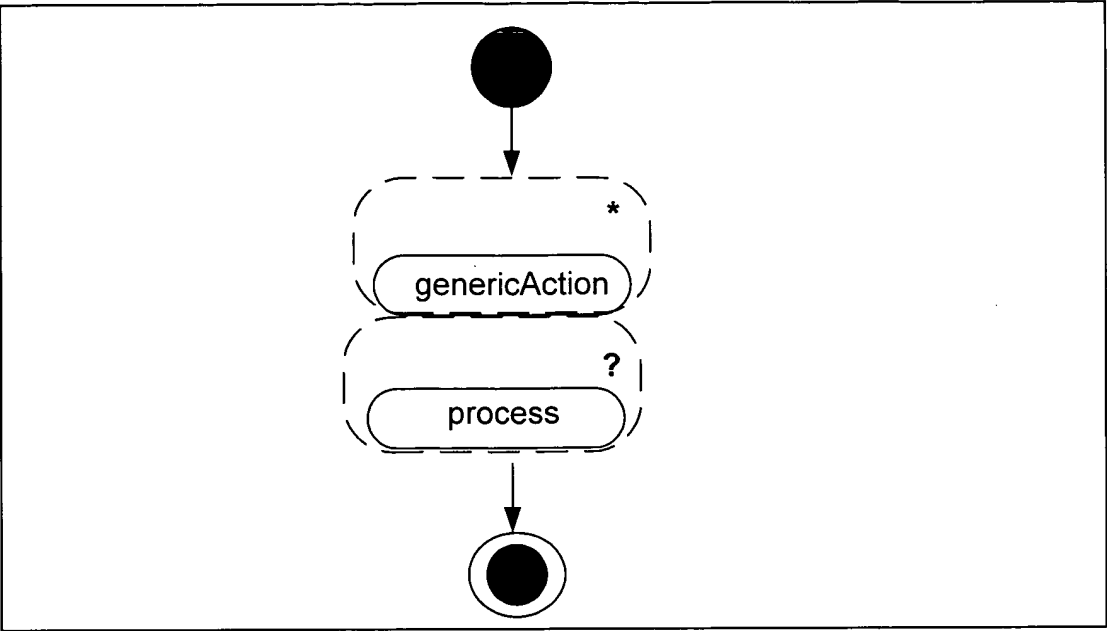


Fig. 14c

Example
<pre> <sequence> <sink> <portRef location="p0"/> <messageRef location="m0"/> </sink> <source> <portRef location="p1"/> <messageREf location="m1"/> </source> </sequence> </pre>

Fig. 14d

Silence (EBNF)
silence ::= zero

Fig. 15a

Silence (XML)
<!ELEMENT silence EMPTY>

Fig. 15b

task	::= action* choice? ctxtRef?
choice	::= <i>all</i> <i>any</i>

Fig. 16a

```
<!ELEMENT task ((sink|source)*, contextRef?)>
<!-- ATTLIST task
choice (all / any) "all" -->
```

Fig. 16b

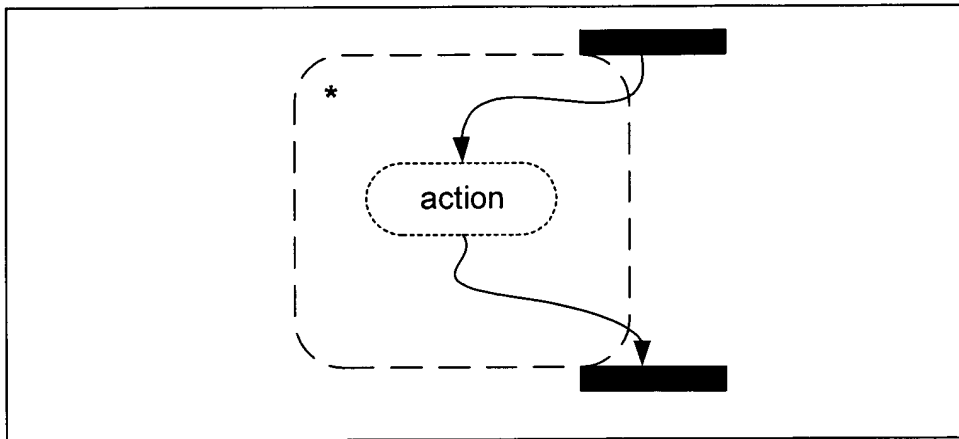


Fig. 16c

Example

```
<task>
  <source>
    <portRef location="p0"/>
    <messageRef location="m0"/>
  </source>
  <source>
    <portRef location="p1"/>
    <messageRef location="m1"/>
  </source>
</task>
```

Fig. 16d

Switch (EBNF)	
switch	::= branch* default? contextRef?
branch	::= case process contextRef?
case	::= case ruleRef messageRef messageRef
ruleRef	::= <i>ruleRef</i> URI
default	::= default process

Fig. 20a

Switch (XML)	
< !ELEMENT switch (branch* default? contextRef?)>	
< !ELEMENT branch (case, (zero sequence switch map copy partition connect cut), contextRef?)>	
< !ELEMENT case (ruleRef, messageRef, messageRef)>	
< !ELEMENT ruleRef EMPTY>	
< !ATTLIST ruleRef location CDATA #REQUIRED>	
< !ELEMENT default (zero sequence switch map copy partition connect cut), contextRef?)>	

Fig. 20b

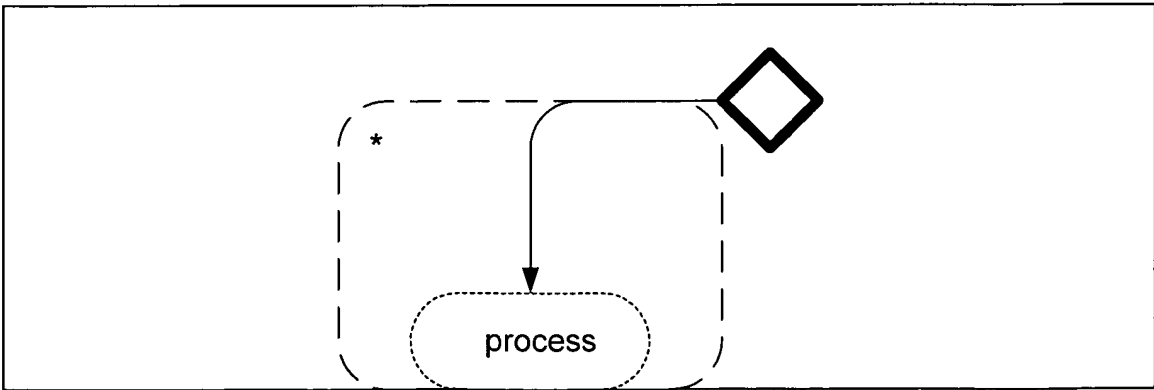


Fig. 20c

```

Example
<schedule name="loopExample">
  <header>
    <portList>
      <port name="p"/>
    </portList>
    <messageList>
      <message name="mTrue"/>
      <message name="m"/>
    </messageList>
  </header>

  <switch>
    <branch>
      <case>
        <ruleRef location="test"/>
        <msgRef location="mTrue"/>
        <msgRef location="m"/>
      </case>
      <sequence>
        <sink>
          <portRef location="p"/>
          <msgRef location="m"/>
        </sink>
        <call>
          <scheduleRef location="loopExample"/>
          <portRef location="p"/>
        </call>
      </sequence>
    </branch>
  </switch>
</schedule>

```

</call>

Fig. 20d

Map (XML)
<!ELEMENT map ((zero sequence switch copy partition connect cut), assignmentList, contextRef?)>
<!ELEMENT assignmentList (assignment*)>
<!ELEMENT assignment (messageRef, portRef)>

```

Example
<map>
  <assignmentList>
    <assignment>
      <messageRef location="m0"/>
      <portRef location="p1"/>
    </assignment>
  </assignmentList>
  <sequence>
    <sink>
      <portRef location="p0"/>
      <messageRef location="m0"/>
    </sink>
    <source>
      <portRef location="p1"/>
      <message location="m1"/>
    </source>
  </sequence>
</map>

```

Fig. 21c

copy

$$:: = \text{copy process contextRef?}$$

Fig. 22a

```
<!ELEMENT copy ( (zero | sequence | switch | map | copy |
partition | connect | cut), contextRef? )>
```

Fig. 22b

partition

$$:: = \text{process}^* \text{ contextRef?}$$

Fig. 23a

```
<!ELEMENT partition ((zero | sequence | switch | map |
copy | partition | connect | cut)*, contextRef?)>
```

Fig. 23b

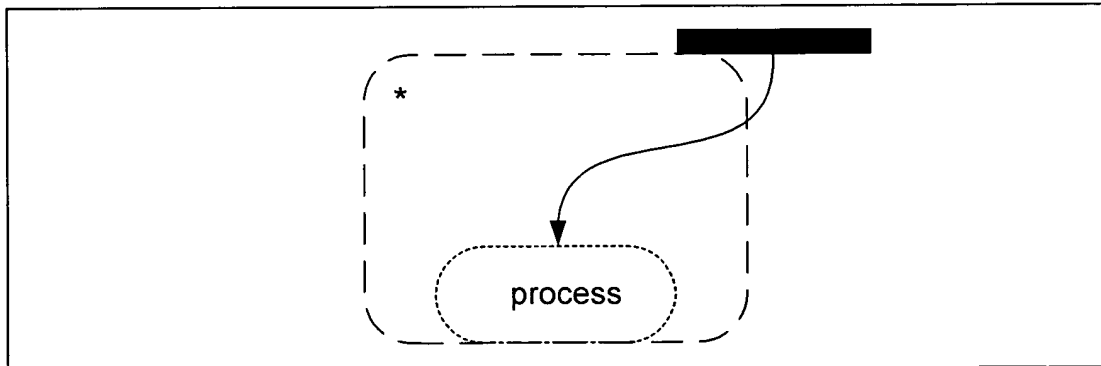


Fig. 23c

connect

```
 ::= process process connectionList contextRef?
```

connectionList
$$::= \text{connectionList portRef PortRef}$$

Fig. 24a

Connect (XML)
<code><! ELEMENT connect ((zero sequence switch map copy partition connect cut), (zero sequence switch map copy partition connect cut), connectionList, contextRef?)></code>
<code><! ELEMENT connectionList (connection*)></code>
<code><! ELEMENT connection (portRef, portRef)></code>

Fig. 24b

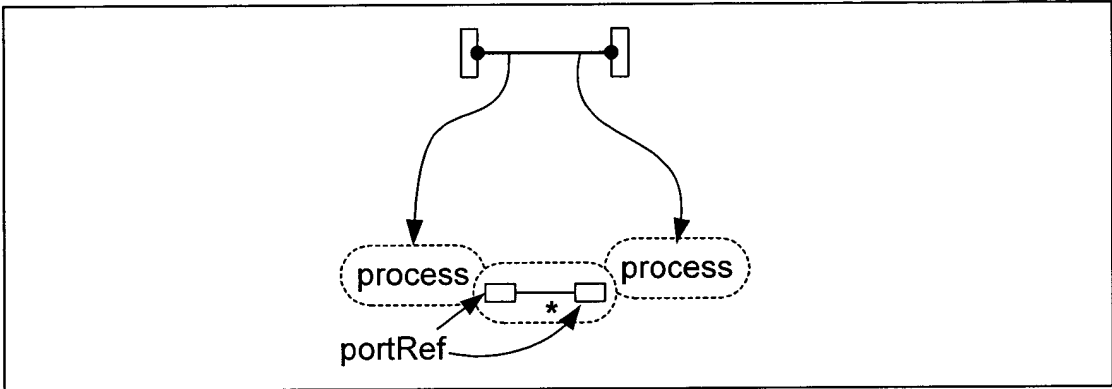


Fig. 24c

Cut (EBNF)
<code>cut ::= process process process contextRef?</code>

Fig. 25a

Cut (XML)
<code><! ELEMENT cut ((zero sequence switch map copy partition connect cut), (zero sequence switch map copy partition connect cut), (zero sequence switch map copy partition connect cut), contextRef?)></code>

Fig. 25b

```

<map>
  <cut>
    <partition>
      <sequence>
        <sink> <portRef location="x"/> <messageRef location="y"/> </
sink>
      </sequence>
      <sequence>
        <source> <portRef location="u"/> <messageRef location="y"/> </
source>
      </sequence>
    </partition>
    <partition>
      <sequence>
        <sink> <portRef location="u"/> <messageRef location="y"/> </
sink>
      </sequence>
      <sequence>
        <source> <portRef location="z"/> <messageRef location="w"/> </
source>
      </sequence>
    </partition>
    <sequence>
      <sink> <portRef location="u"/> <messageRef location="v"/> </sink>
    </sequence>
  </cut>
  <assignmentList>
    <assignment>
      <messageRef location="y"/> <portRef location="z"/>
    </assignment>
  </assignmentList>
</map>

```

Fig. 26a


```

<connect>
  <sequence>
    <sink> <portRef location="x"/> <messageRef location="y"/> </sink>
  </sequence>
  <sequence>
    <source> <portRef location="z"/> <messageRef location="w"/> </
source>
  </sequence>
  <connectionList>
    <conection>
      <portRef location="x"/> <portRef location="z"/>
    </conection>
  </connectionList>
</connect?

```

Fig. 26b

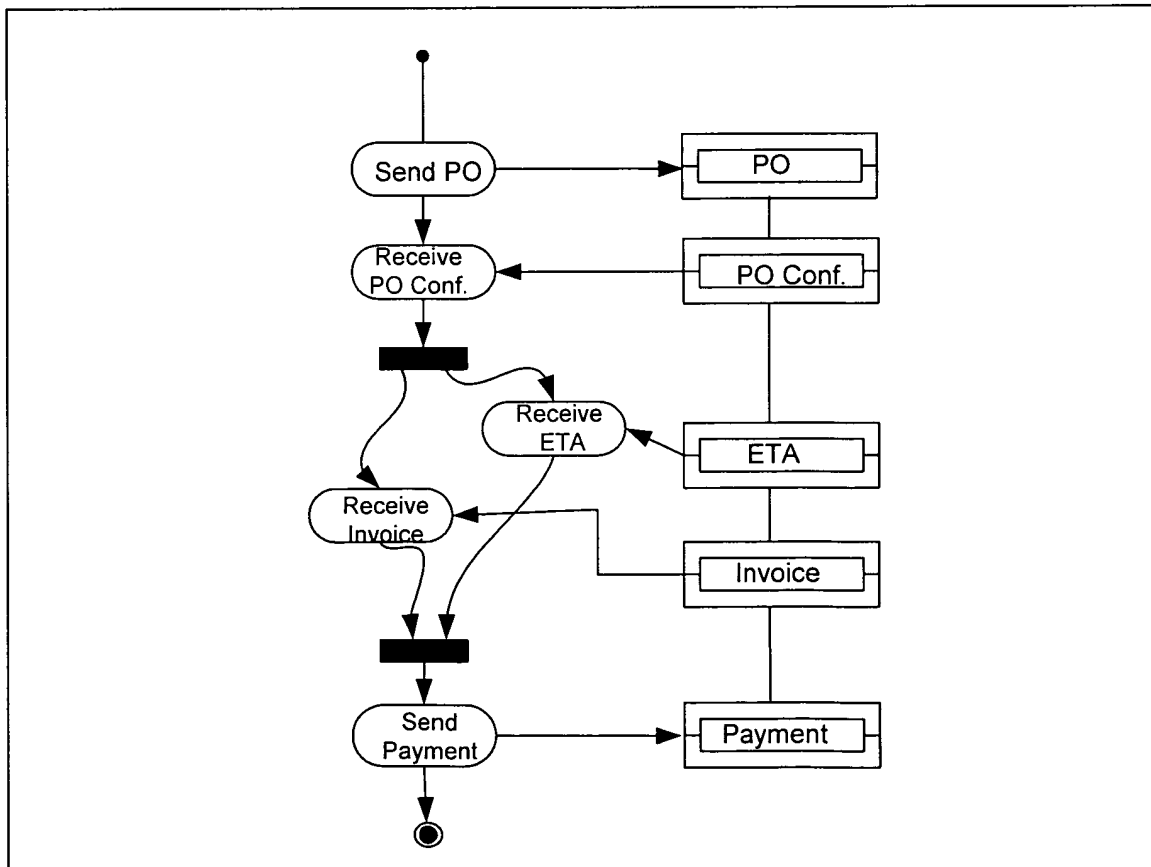


Fig. 27a

```

01 <schedule name="customer">
02
03 <header>
04     <portList>
05         <port name="pSendPO"/>
06         <port name="pReceiveConf"/>
07         <port name="pReceiveETA"/>
08         <port name="pReceiveInvoice"/>
09         <port name="pSendPayment"/>
10     </portList>
11     <messageList>
12         <message name="mPO"/>
13         <message name="mConf"/>
14         <message name="mETA"/>
15         <message name="mInvoice"/>
16         <message name="mPayment"/>
17     </messageList>
18 </header>
19
20 <sequence>
21     <source> <portRef location="pSendPO"/>
22             <messageRef location="mPO"/> </source>
23     <sink> <portRef location="pReceiveConf"/>
24           <messageRef location="mConf"/> </sink>
25 <task>
26     <sink> <portRef location="pReceiveETA"/>
27           <messageRef location="mETA"/> </sink>
28     <sink> <portRef location="pReceiveInvoice"/>
29           <messageRef location="mInvoice"/> </sink>
30 </task>
31 <source> <portRef location="pSendPayment"/>
32         <messageRef location="mPayment"/> </source>
33 </sequence>
34
35 </schedule>

```

Fig. 27b

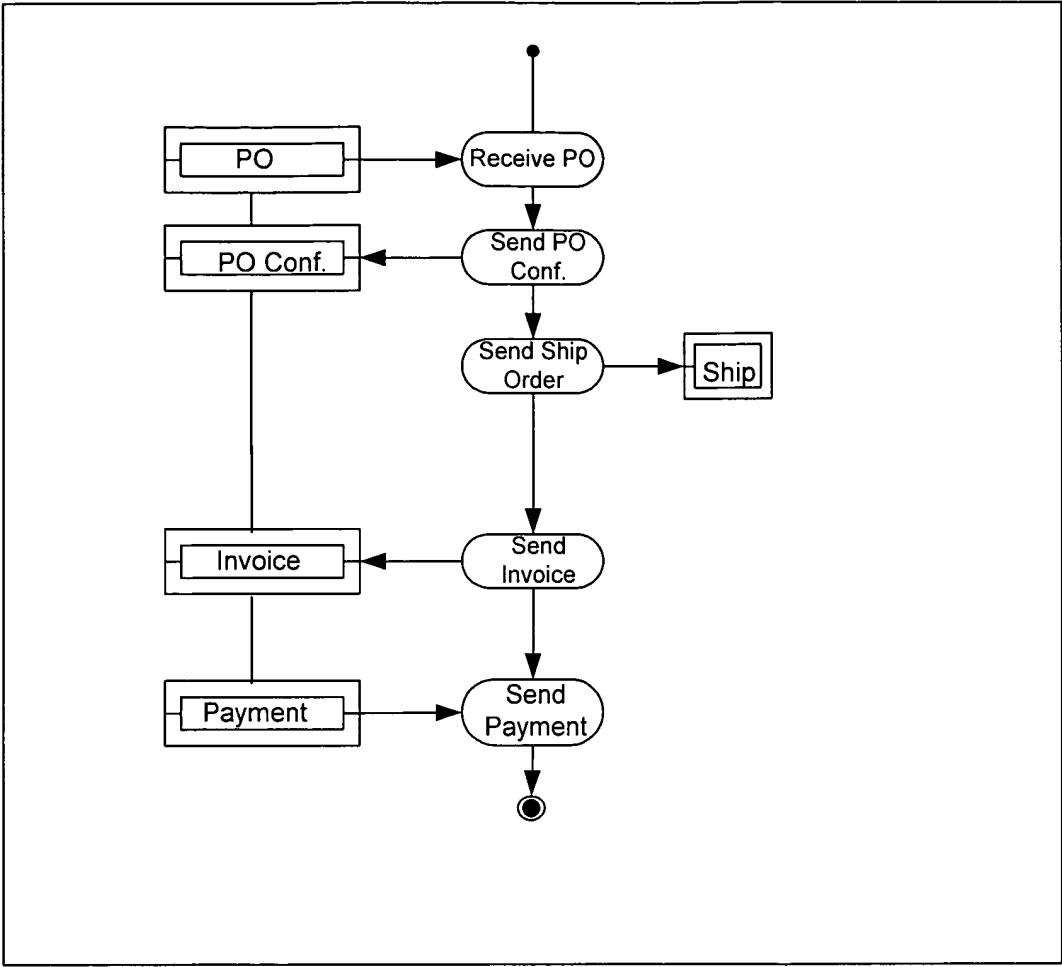
[illegible]

Fig. 28a

```

01 <schedule name="supplier">
02
03 <header>
04   <portList>
05     <port name="pReceivePO"/>
06     <port name="pSendconf"/>
07     <port name="pSendShip"/>
08     <port name="pSendInvoice"/>
09     <port name="pReceivePayment"/>
10   </portList>
11   <messageList>
12     <message name="mPO"/>
13     <message name="mConf"/>
14     <message name="mShip"/>
15     <message name="mInvoice"/>
16     <message name="mPayment"/>
17   </messageList>
18 </header>
19
20 <sequence>
21   <sink> <portRef location="pReceivePO"/>
22         <messageRef location="mPO"/> </sink>
23   <source> <portRef location="pSendConf"/>
24           <messageRef location="mConf"/> </source>
25   <source> <portRef location="pSendShip"/>
26           <messageRef location="mShip"/> </source>
27   <source> <portRef location="pSendInvoice"/>
28           <messageRef location="mInvoice"/> </source>
29   <sink> <portRef location="pReceivePayment"/>
30         <messageRef location="mPayment"/> </sink>
31 </sequence>
32
33 </schedule?

```

Fig. 28b

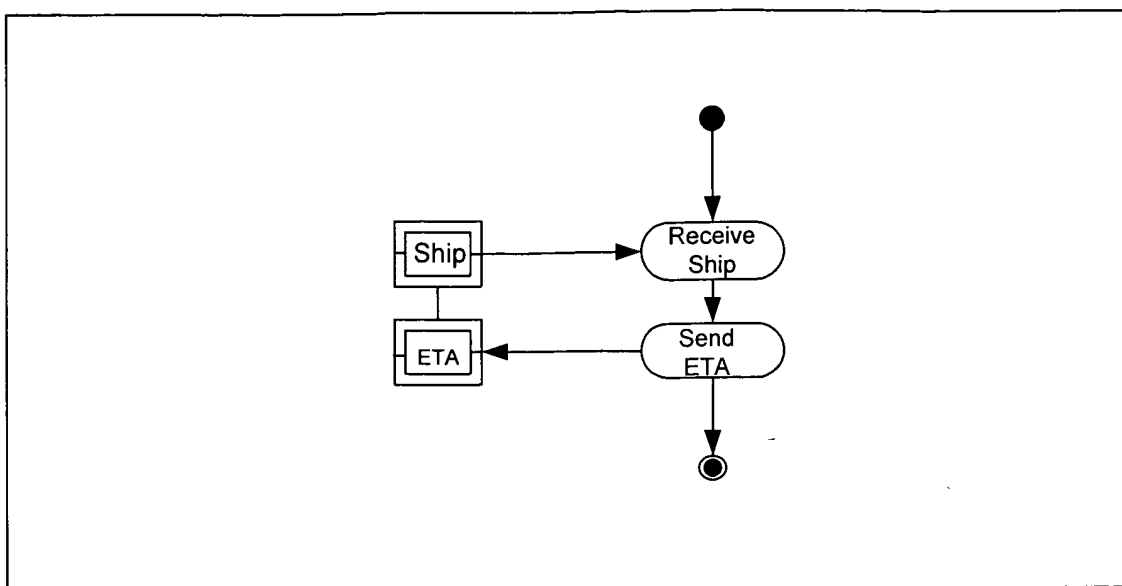


Fig. 29a

```

01  <schedule name="shipper">
02
03  <header>
04    <portList>
05      <port name="pReceiveShip"/>
06      <port name="pSendETA"/>
07    </portList>
08    <messageList>
09      <message name="mShip"/>
10      <message name="mETA"/>
11    </messageList>
12  </header>
13
14  <sequence>
15    <sink> <portRef location="pReceiveShip"/>
16          <messageRef location="mShip"/> </sink>
17    <source> <portRef location="pSendETA"/>
18            <messageRef location="mETA"/> </source>
19  </sequence>
20
21  </schedule>
  
```

Fig. 29b

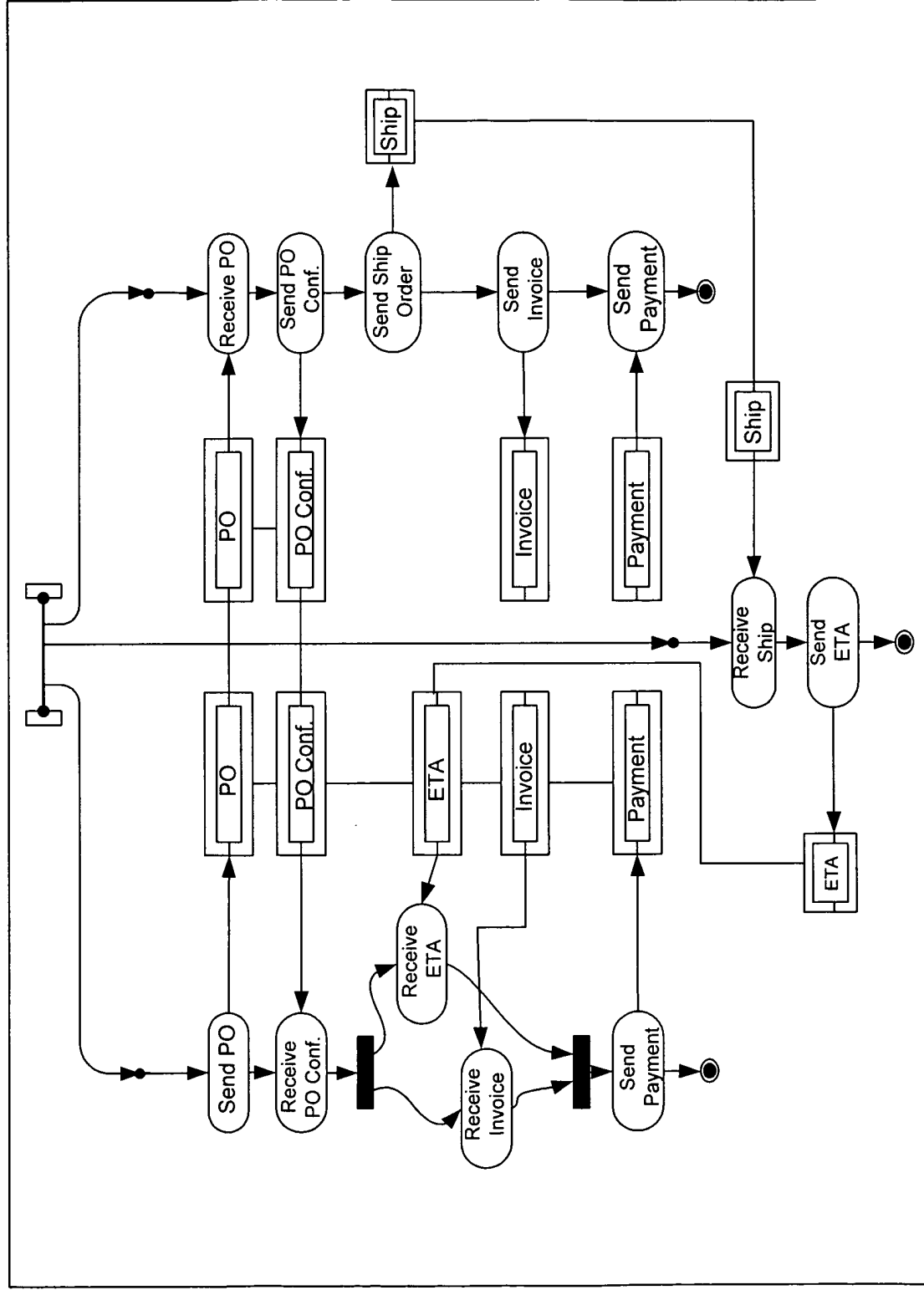


Fig. 30a

```
01  <schedule name="customerSupplier">
02
03  <header>
04    <portList>
05      <port name="pCustomerPO"/>
06      <port name="pSupplierPO"/>
07      <port name="pCustomerPOConf"/>
08      <port name="pSupplierPOConf"/>
09      <port name="pCustomerETA"/>
10      <port name="pSupplierETA"/>
11      <port name="pCustomerInvoice"/>
12      <port name="pSupplierInvoice"/>
13      <port name="pCustomerPayment"/>
14      <port name="pSupplierPayment"/>
15      <port name="pSupplierShip"/>
16      <port name="pShipperShip"/>
17    </portList>
18  </header>
19
20  <connect>
21    <sequence>
22      <call> <schedRef location="customer"/>
23        <portRef location="pCustomerPO"/>
24        <portRef location="pCustomerPOConf"/>
25        <portRef location="pCustomerETA"/>
26        <portRef location="pCustomerInvoice"/>
27        <portRef location="pCustomerPayment"/> </call>
28    </sequence>
29    <connect>
30      <sequence>
31        <call> <schedRef location="supplier"/>
32          <portRef location="pSupplierPO"/>
33          <portRef location="pSupplierPOConf"/>
34          <portRef location="pSupplierShip"/>
35          <portRef location="pSupplierInvoice"/>
36          <portRef location="pSupplierPayment"/> </call>
37      </sequence>
38      <sequence>
39        <call> <schedRef location="shipper"/>
40          <portRef location="pShipperShip"/>
41          <portRef location="pSupplierETA"/> </call>
42      </sequence>
```

Fig. 30b

```

43     <connectionList>
44         <connection> <portRef location="pSupplierShip"/>
45                     <portRef location="pShipperShip"/> <connection>
46     </connectionList>
47 </connect>
48 <connectionList>
49     <connection> <portRef location="pCustomerPO"/>
50                 <portRef location="pSupplierPO"/> </connection>
51     <connection> <portRef location="pCustomerPOConf"/>
52                 <portRef location="pSupplierPOConf"/> </connection>
53     <connection> <portRef location="pCustomerETZ"/>
54                 <portRef location="pSupplierETA"/> </connection>
55     <connection> <portRef location="PCustomerInvoice"/>
56                 <portRef location="pSupplierInvoice"/> </connection>
57     <connection> <portRef location="pCustomerPayment"/>
58                 <portRef location="pSupplierPayment"/> </connection>
59 </connectionList>
60 </connect>
61
62 </schedule>

```

Fig. 30c